UNIVERSITI PUTRA MALAYSIA

IMPACT OF RODENTS ON POULTRY PRODUCTION IN UPMKB

MUHAMAD ZAKI MAT DAUT

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MUHAMAD ZAKI BIN MAT DAUT

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ABSTRACT

A study of impact of rodents on poultry production in poultry farm had been conducted in Universiti Putra Malaysia Bintulu Campus. The purpose of the study was to identify the types of rodent species around chicken barn at UPMKB, study the impact of rodents on the production of poultry in UPMKB and lastly identify a management plan to control the rodent's population in UPMKB chicken barn so that the total feed loss can be reduced. A practical strategy for maintenance baiting of rodents in high-rise includes the utilization of a rotating bait container technique. This technique eliminates the requirement for many bait containers and the work required to place out, pick up, and trap every compartment container. Total of twenty traps are placed randomly around the chicken barn for about 2-month period. *Rattus norvegicus* was the dominant rat species in the study area because all 16 total individual rodents captured there are the same species and sexes. The study also found that the rodents had been affecting poultry production of UPMKB in greater values and also spread diseases to chicken there beside contaminating the food there. Rodent management is important to shield the food production chain from wellbeing dangers to domesticated animals and people. Some organic ranchers incline toward biological rodent control, yet since rodents can also transmit diseases this bears certain dangers for the production of healthy livestock and safe food. Viable rodent administration requires a thorough comprehension of the biology of the pest species concerned. Wild rats ought to be thought to be disease risk components to poultry whose pens they visit.

Development and maintenance of useful barriers will improve rodent control and limit poisoning in domestic animals living on the barn.

ABSTRAK

Kajian mengenai kesan tikus pada pengeluaran unggas di kandang ayam telah dijalankan di Universiti Putra Malaysia Kampus Bintulu. Tujuan kajian ini adalah untuk mengenal pasti jenis spesies tikus di kandang ayam di UPMKB, mengkaji kesan tikus pada pengeluaran unggas di UPMKB dan akhirnya mengenalpasti rancangan pengurusan untuk mengawal bilangan tikus di kandang ayam UPMKB supaya jumlah kehilangan makanan boleh dikurangkan. Teknik praktikal untuk penyelenggaraan umpan tikus dalam peningkatan tinggi melibatkan penggunaan kaedah penampung umpan berputar. Kaedah ini mengurangkan keperluan untuk menggunakan banyak bekas umpan dan tenaga buruh yang diperlukan untuk meletakkan, mengambil, dan memastikan umpan di setiap bekas. Sejumlah dua puluh perangkap diletakkan secara rawak di kandang ayam dalam tempoh selama 2 bulan. *Rattus norvegicus* adalah spesies tikus dominan di kawasan kajian kerana kesemua 16 tikus individu yang ditangkap merupakan dari spesies dan jantina yang sama. Kajian itu juga mendapati bahawa tikus telah mempengaruhi pengeluaran unggas UPMKB dalam nilai yang amat besar dan juga menyebarkan penyakit kepada ayam di sana selain mencemarkan makanan di sana. Pengurusan tikus diperlukan untuk melindungi rantaian pengeluaran makanan dari membahayakan kesihatan ternakan unggas dan manusia. Sesetengah petani organik memilih kawalan tikus secara biologi, tetapi tikus juga boleh menyebarkan penyakit dan mereka perlu menanggung risiko tertentu untuk pengeluaran ternakan yang sihat dan makanan yang selamat. Pengurusan tikus yang berkesan memerlukan pemahaman yang mendalam mengenai biologi

spesies perosak berkenaan. Tikus liar harus dipertimbangkan sebagai faktor risiko penyakit kepada ayam yang mereka kunjungi. Pembinaan dan penyelenggaraan halangan akan berfungsi untuk meningkatkan kawalan tikus dan mengehadkan keracunan pada haiwan domestik yang tinggal di bangsal.

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Not to forget my family, who has given me motivation and love throughout all the period of the study. Without their support, the anxiety and nervousness will have engulfed me and cannot go on with this study.

May Allah Bless us all.

APPROVAL SHEET

I certify that this research project entitled "Impact of Rodents on Poultry Production in UPMKB" has been examined and approved as a partial fulfilment of the requirement for the degree of Bachelor of Bioindustrial Science in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus.

Dr. Zamri Bin Rosli
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Sarawak Campus
(Supervisor)

En. Philip Lepun
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Sarawak Campus
(Co-Supervisor)

Prof. Madya Dr. Shahrulrazid Bin Sarbini
Dean
Faculty of Agriculture and Food Sciences
Universiti Putra Malaysia Bintulu Sarawak Campus

Date:

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Business poultry production is quickly growing worldwide to address the needs of the expanding human population. Further, with the decreased cost and upgraded wages per capita, poultry meat consumption is expanding. Numerous poor and white-collar class farmers in developing countries are taking up poultry to supplement their salary and this industry has turned into a major noteworthy income source to them. The business has been developing at 2-3% per year and is relied upon to proceed with expansion in the foreseeable future.

This vast poultry industry requires broad extensive housing for the birds to increase the meat and egg production. This intensive production by housing a substantial number of people in moderately little territory produces large quantities of wastes (manure, utilized litter, dead birds) and provides great condition for the exponential development of arthropod and rodent pests. Subsequently, successful pest management became an essential part for poultry industry.

Rodent pests contribute critical losses to poultry cultivation throughout the world. It is difficult to estimate precisely the misfortunes caused by rodent pests in the poultry situation since both qualitative and quantitative losses occur. There is no coordinated exertion also to gauge the rodent borne losses.

The Rodentia make up over 40% of mammal species and represent the largest order of mammals, comprising some 2277 species in 30 extant families that include 481 genera (Wilson and Reeder 2005). A further 12 families and 300 genera are known only from fossils. Their principle unifying feature is the possession of one pair of incisors above and below the use of these for gnawing. Over the past two decades, as taxonomists continue to develop techniques with which to describe rodent phylogeny, so there has been much debate as to their monophyletic origin.

The name of the order is derived from the Latin *rodere*, meaning to gnaw. Rodent's incisors are remarkable both in their length with the open roots of the lower pair reaching back almost to the articulation of the jaw – and in their structure – with only the front surface being coated with enamel. This enamel wears less quickly than the softer dentine behind, thus producing a self-sharpening blade. There is a gap, the diastema, between the incisors and the rest of the definition. The number and appearance of the cheek teeth vary widely between species.

Apart from sight, which is poor in the majority of rodent species (blind rats and mice appear to survive adequately) (Meehan 1984), rodents generally have very acute senses, and smell, hearing, touch and taste are well developed. Social odours play an enonnous role in rodent biology, both through a direct impact on behaviour and through the physiological impact of primer pheromones (Johnston 2003).

Rodents happen in essentially every terrestrial condition that supports life, be it wild, agricultural or urban. Numerous species involve moderately small people with the ability to multiply quickly. Generally, rodents are omnivorous, sustaining mainly on plant materials, which may include seeds, leaves, roots, entire young plants, fruit, grain and tree bark, and animal tissue, for instance, insects, snails, other invertebrates and the bodies of vertebrates.

They may likewise feast upon living plants and animals, and by scavenging. A few animal varieties are fairly restricted in diet, yet most are very flexible, and some can adjust readily to manufactured food products and wastes. Numerous species are fossorial, nesting and living a significant part of the time in burrows; others inhabit at ground level, advancing through tree climbing to completely arboreal species. Rodents are represented in every single climatic zones from Artic tundra to the equatorial tropics, and they include species that are well adapted to arid and dry conditions.

In the same manner with most taxonomic groups, rodents demonstrate a tendency to having a more prominent number of species in warmer, wetter environments. All of these attributes predispose rodents to live freely in rivalry with humans (in example, to be pests), including their part in important ravaging in agriculture (wide sense). Rodents can cause major issues due to destruction and contamination of food, and also by the spread of various diseases.

The damage caused by rodents may sometimes be estimated roughly for local districts where a measurable proportion of various crops is destroyed by the rodents (Singleton *et al.* 1999).

1.2 Problem Statement

The total population of annual poultry production in UPMKB are diminishing due to:

i. Diseases spreading via the rodents because it is recognized as carriers of approximately 45 diseases and carry disease-causing organisms on their feet, increasing the spread of disease.
ii. Declining of poultry food that often be consume by the rodents, thus a competition for food with the poultry and also, they can contaminate the food 10 times the amount of feed it eats with its droppings, urine and hair.

1.3 Objectives

i. To identify the type of rodent species around chicken barn at UPMKB

ii. To study the impact of rodents on the production of poultry in UPMKB

iii. To identify a management plan to control the population of rodent in UPMKB chicken barn.

CHAPTER 2

LITERATURE REVIEW

2.1 Rodents

Rodents are a unique order in the mammalian class, and their idiosyncrasy goes a long way past the fact that they are the most species-rich order: 2,277 of the 5,419 mammalian species are rodents (i.e. 42% of all species. There is no other vertebrate order with such a high assorted variety of pest species, such as widespread range, and such variety of impacts, in agriculture, urban areas, ecosystems, forestry, public health, etc. (Singleton *et al.* 1999). For instance, between 1998 and 2008, in excess of 23,000 cases of human plague, an infectious disease caused by *Yersinia pestis* which is conveyed by *Rattus rattus* as intermediate host, were accounted for, including 2,116 fatalities in 11 countries. Rodents are among the most essential worldwide pests (Prakash 1988; Singleton *et al.* 1999a), and are regularly highlighted in fiction, as in Albert Camus '*The Plague*'. Farmers in numerous parts of the world, especially those in developing countries, tend to view economic losses because of rats and mice as unavoidable (Posamentier 1997; Singleton *et al.* 1999).

The cost of rodent pests to agriculture is tremendous (Singleton *et al.* 2010). In Asia, the preharvest loss of rice *Oryza sativa* because of rodents – either local or non-local – is evaluated to be 5% of the production, or roughly 30 million metric tonnes: enough rice to feed 180 million individuals for a year; the postharvest losses are most likely of a similar magnitude (Singleton 2003). The worldwide business activities related with pest control is thusly immense, ranging from manufacturing of pest control products to exceedingly qualified pest control services provided to e.g. householders and food industries in urban territories (Langton *et al.* 2001).

At the point when introduced outside their normal range, numerous rodents, for example, rats, mice, squirrels and coypus may have a detrimental effect on local species and ecosystems, requiring the implementation of control or annihilation programs. The outline of rodent control strategies has both an ecological measurement, relating to the connection of the pest population and its resources and enemies (Singleton *et al.* 1999a), and an economic measurement, relating to crop damage, which influences yield, and the utilization of pesticides, which thusly influences production costs (Carlson and Wetzenstein 1993).

The abundance and diversity of rodent pest species and effects has driven, through the centuries, to outrageous diversification of control techniques and devices. Attempts to trap, repel and poison rodents have happened throughout the centuries: as an example, the utilization of naturally-derived poisons (mainly based on hellebore, black henbane, hemlock, and wild cucumber) to annihilate rats and mice around houses and storehouses were suggested in ancient Greece and Rome (Smith and Secoy 1975).

Regardless of this long history of fighting against rodents, no conclusive solution has been found yet, and different control techniques are currently utilized throughout the world (Buckle 1994, Smith 1994, Singleton *et al.* 1999) for reviews. The worldwide versatile radiation of strategies, however, may determine a dynamic absence of shared opinion in the different research lines.

Rats have been seen to show solid hoarding behaviour in an attempt to dodge conspecific aggression, especially when hungry or lactating (Clapperton 2006). This attribute is also evidently more pronounced in black rats contrasted to Norway rats (Clapperton 2006). Food carrying behaviour, however, might be inaccurately interpreted as hoarding, particularly among Norway rats (Takahashi and Lore 1980). Takahashi and Lore (1980) found no proof of stored food in any of the Norway rat burrows that were exhumed. Similarly, no confirmation of caching was found among a population of wild Norway rats, in spite of the fact that the rats did show a strong tendency towards consuming food in particular areas within their home territory (Whishaw and Whishaw 1996). Rats are generally nocturnal and regularly often forage shortly before or at sunset (Barnett and Spencer 1951). Whishaw and Whishaw (1996) and Takahashi and Lore (1980) found that the majority of rat activity tends to happen before 12 a.m., after which very few rats are located (Takahashi and Lore 1980; Whishaw and Whishaw 1996). Younger rats, however, may forage earlier in the day to avoid competition from older, larger rats (Whishaw and Whishaw 1996). Rain and inclement climate have been reported to discourage outdoor rat activity (Frantz and Comings, 1976; Whishaw and Whishaw 1996), while presence of peoples does not seem to bother rats or modify their feeding patterns (Takahashi and Lore 1980; Whishaw and Whishaw 1996).

A wild rat may visit a food site a few times a night, in any case, there are significant sex-related contrasts in foraging behaviour (Inglis *et al.* 1996). Females scavenge in numerous short visits, while males will forage less frequently but for longer periods at a time (Inglis *et al.* 1996). Pregnant and lactating females, however, will devour bigger meals and feed for longer than males (Clapperton 2006). Total amount of food devoured does not differ significantly by sex but is more subjected on the body weight of the rat (Inglis *et al.* 1996) and the caloric value of the food (Barnett 1963). Overall, rats will alter their feed intake to meet individual energy requests.

Rats show exploratory behaviour while foraging (Barnett and Spencer 1953). This behaviour enables rats to gather data on local topography, as well as the whereabouts of food, water, and safe house (Barnett 1956). Rats also demonstrate a tendency to sample food, approaching a new source carefully before retrieving a piece and making a quick withdraw (Whishaw and Whishaw 1996). It is through this sampling behaviour that food associations are found out (i.e., whether a food is nutritious or toxic) (Barnett 1956), and rats will show this behaviour regardless of circumstance, age, or sex (Barnett 1956).

2.2 Competing with Rodents for Food

Around the world, there are about 1700 species of rodents, yet just 5–10% are major nuisance species in agricultural and urban environments, and even less cause problems over bigger geographic zones. Some of these devour substantial amounts of agricultural produce (Table 1), and in numerous developing countries, agriculturists consider rodents the main obstacle to higher yields (Makundi *et al.* 1999). Every year, rats in Asia consume food crops that could sustain 200 million individuals for a whole year (Singleton 2003). In Indonesia, rodents are the most vital pre-harvest pests in economic terms, causing on average at least 15% yearly losses of rice (Geddes 1992).

The plan of rodent control strategies has both an environmental dimension, relating to the interaction of the pest population and its assets and enemies (Singleton *et al.* 1999), and a monetary dimension, relating to crop damage, which influences yield, and the utilization of pesticides, which in turn affects production costs (Carlson and Wetzenstein 1993). Bio-economic investigation of pest control has been connected disproportionately to invertebrate pests and weeds, whereas vertebrate pests have been greatly ignored.

Rodents flourish on the rich food supply provided by the agricultural production system. The application of rodent control is often frequently ineffectively coordinated or insufficient, so that populations recover rapidly, or else control is performed in response to high rodent numbers, after the damage has been finished. We need a better understanding of the trade-off between the costs and benefits of control. The result of a cost–benefit analysis will depend on, for instance, the value of a crop, the planning, and the cost and effectiveness of control techniques.

2.3 Feed Loss

Rodents eat poultry feed and they squander and contaminate more than they eat. With an unassuming appraisal of their feed consumption at 10% of their body weight, the rats devour about 25 g per day and 9.1 kg per year. If that daily figure is converted to a yearly estimate and if as many as 20 rats are available in a poultry shed, the annual loss per shed could reach 0.18 tonnes. Rats take 10 g feed for day but destroy 10 times of feed and poultry chickens declined to take such polluted feed. This refused polluted food is unaccounted, while taking rodent related losses. Estimation by the ICAR Rodent Research Project reported that feed loss ranging from 0.05 to 0.14 kg in sheds, 0.18 to 6.38 kg in feed store and spillage up to 20kg/day in heavily infested poultry houses. In addition to the feed loss, rodents also spoil the feed through their spillage behaviour. Feed spillage losses were never scientifically estimated.

2.4 Nuisance Value

Moreover, rodents cause general nuisance for chickens in the poultry house due to their noise and movements. This startles the chickens resulting in poor performance. The rodents also cause high death rates of chicks and production losses. Rats have been known to kill baby chicks and break and eat eggs and panicked chickens by their movements or by noises they make. Research has shown that by decreasing the rodent population in poultry houses, the chicken death rate can also be brought down.

2.5 The Common House Rat (*Rattus rattus*)

The common house rat is a form of the widespread rat species called *Rattus rattus*. The first form to be described was the black form found in Northern Europe, commonly called the 'black rat' in books, although in fact most examples, even in Europe, are brown. In Malaysia this rat is represented by a brown form with a dull greyish brown belly. It is a medium-sized rat with the head and body (HB) between 110 and 200 mm in length and a darkish tail which is as long as or slightly shorter than the HB length. It is predominately an indoor rat, dwelling in store-rooms, attics and other secluded places and living on the food that is available indoors.

In poorly-constructed houses, the attic is a refuge for all kinds of animals such as rats, birds, bats and snakes and it serves as a common platform for predator/prey encounters. It is not uncommon for such houses to be visited by the common civet or Musang Pulut *(Paradoxurus hermaphroditus)*—in most cases a female with a few juveniles, or a female nursing new born puppy. The rats would horde together hoping to predate on the puppies and would be repelled by the parent Musang, which is a larger animal. Such encounters create a loud drumming commotion that can often be heard at night.

Distribution and status: The house rat is widespread throughout Malaysia and is common in all Southeast Asian countries. It differs in number of chromosomes from the form of *Rattus rattus* that is native to India.
Ecology and habitat: Nocturnal, terrestrial and omnivorous, feeding on garbage and household waste, plant and animal matters. It is primarily associated with human habitations, preferring indoor environments. It contaminates food through urination in store houses, provision shops and homes. Those that cannot find indoor accommodation will build their burrows in rubbish dumps and road sides and thrive on garbage and food waste. In areas where plots of rice, orchards and vegetables are situated adjacent to households, it is not unusual to find this rat as an opportunistic pest in the absence of the field rodent species, though it spends most of its time on the ground, this rat is also a good climber.

Black rats specially consume fruits, nuts, and seeds (Marsh 1994), while Norway rats, being more omnivorous by nature, will eat a wide exhibit of feedstuffs

(Clapperton 2006). Food inclination in rats is affected by previous experience and dietary estimation of food (Barnett and Spencer 1953). However, rats are fantastically opportunistic and will adjust to an assortment of foods, therefore food selection is largely determined by availability (Traweger and Slotta-Bachmayr 2005). In the case of urban rats, refuse is a source of food for both black and brown rats, especially in the absence of more natural resources (Glass *et al.* 1988; Traweger and Slotta-Bachmayr 2005). That being said, most rats will reject food that is spoiled (Glass *et al.* 1988). Feeding behaviour in rats is best anticipated by time taken to devour food, which is, in turn, dictated by the size of the food stuff (Whishaw and Whishaw 1996). Little bits of food (crumbs, flour, wheat, etc.) are eaten straightforwardly where they are found, while bigger pieces tend to be conveyed to a secluded territory for undisturbed utilization (Barnett and Spencer 1951; Whishaw and Whishaw 1996). Rats for the most part avoid open areas and tend to feed close to cover (Barnett & Spencer, 1953; Barnett 1956; Takahashi and Lore 1980), with the exception of dominant rats, who will probably consume food directly at the food source (Whishaw and Whishaw 1996). Large food items are frequently chosen preferentially when both little and large items are accessible, and rats may endeavour to gather and carry different food items during a single trip (Whishaw and Whishaw 1996).

2.6 The Norway Rat (*Rattus norvegicus*)

The brown rat (*Rattus norvegicus*) is a types of the family Muridae; the biggest mammalian family (Nowak 1991), order Rodentia and class Mammalia. It is for the most part known to have originated from Asia. Following a progression of accidental introductions, the species had discovered its approach to Eastern Europe by the early eighteenth century. By the year 1800, it happened in each European country (Meyers and Armitage 2004). The brown rat can be found on each mainland of the world aside from Antarctica (Silver 1927; Nowak and Paradiso 1983). In Europe and America, it has been reported to have displaced the black rat (*Rattus rattus*) which had been available since Roman times (Cowan *et al.* 2003). Nowak (1991) however expresses that black rats are more typical than brown rats in the tropical zones. The brown rat in provincial areas is seen predominantly as a storage pest living on the supplies of harvested cereals, root crops and also on livestock feeds that can be found in farm buildings (Cowan *et al.* 2003).

The Norway rat (*Rattus norvegicus*) is also widespread but is more abundant in colder climates. It probably originated as a field rat of the Siberian steppes whence it became domesticated, eventually invading Europe and spreading all over the world. The albino rat, used as an experimental model throughout the world, was derived from this wild stock.

On the average, brown rats are up to 440 mm long, nose to tail and weigh around 200 to 500 g (Nowak 1991). Males are normally bigger than females. The length of the tail is shorter than the length of the body. The ears are relatively shorter than those of different species and do not cover up to the ears when pulled down. Naturally, brown rats are covered with brownish fur on their back which usually lightens to a grey colour near the underside but can also take the colours of a typical black rat, which similarly may take the colour of a typical brown rat. The brown rat can easily be mistaken for black rats, but while the transient edges of brown rats are straight; those of the black rats are otherwise curved (Nowak and Paradiso 1983). Furthermore, the black rat is littler and slenderer built, has a longer, thinner tail (longer than the body), tail is uniformly coloured, and has a more pointed head and larger ears.

It is a large rat with HB length 150-250 mm which is about twice the size of the common house rat. It differs from the latter species by size and colour: the belly is greyish and the tail short and bi-coloured (darker above and whitish underneath). In Malaysia it is a burrowing house pest, living under the floor or in rubbish dumps. The short tail limits its ability to climb high structures, thus confining its activities to the ground.

The Norway or brown rat (*Rattus norvegicus*) is among the most omnipresent of rodents. It lives in nearness proximity to people in cities and is the reason of broad economic damage to farms, food products, industries, and households. In connection to public health, this species is a reservoir for vital zoonotic pathogens such as bacteria (e.g. *Leptospira interrogans*), viruses (e.g. Seoul virus), and helminths (e.g. *Capillaria hepatica*).

Norway rats have a high reproductive rate and behavioural versatility allowing infestations of rural and urban environments. In urban territories, rat possess large amounts of natural surroundings where accumulated human trash and favourable burrowing sites are plentiful. In temperate and tropical cities residential areas, most strikingly of low socioeconomic status, refuse and improperly stored food, lack of sanitation, abandoned properties and poor household conditions all contribute to plentiful rodent populations.

Despite the fact that the Norway rat has a worldwide distribution, most investigation on rat populations have been engaged in temperate zones. These studies have demonstrated that reproductive parameters vary significantly among seasons or natural surroundings (e.g. rural vs urban). The lack of studies depicting Norway rat populations from tropical areas, however, has limited our understanding regarding the similar demography and seasonal dynamics of Norway rat. Older studies have recommended that rat populations change in their reproductive status between seasons in tropical areas, but these studies were conducted without systematic methodologies. Seasonal differences are affected by both biotic and abiotic factors of the environment (e.g. photoperiod, food supply, and weather) that interface to control their development rate and reproductive development.

Brown rats prefer to live alongside the rapid development of human population. Commensalism, which is a human dependent association, is the chosen way of life of brown rats and also black rats. The rat has chosen to be wherever we people choose to live particularly where there is constant supply of food (Myers and Armitage 2004). These rodents possess a variety of habitats including garbage dumps, sewers, open fields, woodlands, feed mills, farm houses and nearly anywhere else that food and shelter can be discovered (Nowak and Paradiso 1983). The normal home range of *Rattus norvegicus* is about 25-150 m in diameter (Grzimek 1975; Taylor and Quy 1978); however, individuals have been known to move as far as 3 km from their nests in a single night (Nowak 1991). The home range and territories are dependent on factors as e.g. population density, food supply, vegetation. Wild rats are known to burrow tunnels which can be a simple passage leading to a chamber or a complex interconnecting tunnels passages and holes (Calhoun 1962). The tunnel for the most part consists of an entrance, a tunnel, and a cavity which could be used as nest cavity or food storage (Calhoun 1962). It has been reported that there are no significant contrasts in the tunnelling behaviour of the domestic and wild rats (Nieder *et al.* 1982).

This rat, once confined to seaport areas, is now well-established as a town and city species due to linear industrialization, with human activity providing ample food and shelter and encouraging propagation.

Distribution and status: Worldwide in distribution, the Norway rat, also known as "seaport or sewage rat" has spread from its normal niche in seaports to inland towns and cities. In most European countries, this species is also adapted to the field environment, causing extensive damage to field crops.

Ecology and habitat: Nocturnal and terrestrial. It builds large burrow systems, thrives in rubbish dumps outdoors, and under the floor in store houses indoors. It has a habit of gnawing electrical wiring, damaging underground wiring and street lighting and causing electrical fire in buildings and houses. In some parts of Malaysia (Sabah, Sarawak, Pulau Langkawi) and a few Southeast Asian countries (Indonesia, Philippines, Myanmar), it occurs in rice fields adjacent to human habitations. It is not as agile as the house rat but is a good swimmer.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Site

The study area was located within the Universiti Putra Malaysia Bintulu Sarawak Campus (Figure 3.1). The chicken barn was built to rear chicken for commercial used and student's practical activity.

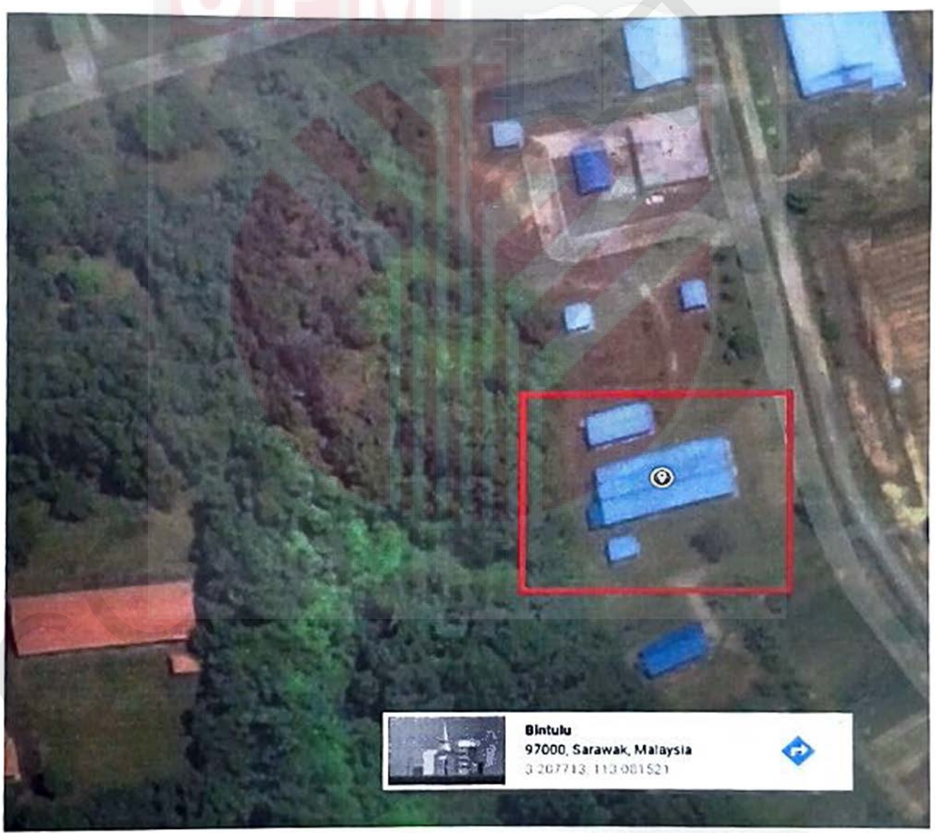


Figure 3.1: The location of UPMKB chicken barn (Source from Google Maps)

Figure 3.2: A view of UPMKB chicken barn

3.2 Sample Collection

The information of rodent was collected at UPMKB chicken barn using live traps method. Trapping is the most secure and best effective method to trap the rodents. The trapping methods are basically the ones that have been utilizing for the last 50 years to study small rodents (Krebs, 1966). Trapping is an effective, brisk and economical control way to deal with supplement baiting programs. Traps can be utilized in place of baits when there are only a few rodents present, or in situation where baits may pose a risk. The approach was dependent on excess traps to avoid trap rivalry and to space the intertrap distance on the trapping grids in such a way as to catch a high division of the rodent present. Live trap will be placed around the chicken barn using different types of bait, such as palm oil fruits, chicken food and salty fish. Traps were covered with a board to protect them from sun and rain. Traps (locked open) were left in place all week. Trapping sessions were conducted over 3 days, and traps were set in the evening of day 1, checked in morning and evening of day 2, and locked open in the last check on the morning of day 3.

3.3 Rotational Baiting

A practical strategy for maintenance baiting of rodents in high-rise and other poultry facilities includes the utilization of a rotating bait container method (Figure 3.3). This method disposes the requirement for many bait containers and the labour required to place out, pick up, and bait each container. Rotation baiting involves placing eight to ten bait containers containing 500 grams. If baiting (use only the single-dose baits) dispersed 10 metres apart along the building perimeter walkways. These containers are then rotated around the house perimeter every third day in 8' increments (e.g., placed at each support pole). The rotation baiting method is most effective in controlling minor and low infestations of mice, or as a maintenance program. It should not be utilized for the initial knockdown of the rodent population.

Baiting single-story and shallow-pit egg-layer operations is comparative in principle to high rise facilities. In these facilities, however, rodents often extensively use the manure and the ground below the manure and walkways for harbourage. In severe infestations, rodents may become established in the manure pit throughout the entire length of the house. Bait placements often have to be made on walkways (or within all dry pits which are harbouring rodents) in addition to all perimeter wall and ceiling baiting as described for high rise facilities. For severe infestations, the entire length of the house should be baited. Plastic bait stations containing 30 to 60 grams of bait (or per label directions) can be placed every 0.4m – 0.7m, (use the shorter distances for severe infestations) at the edge of the slab walkway directly in the pit (if the pit is dry), or if the pit is a wet/slurry pit, the baits can be placed on the edge of the walkway. Baits should be left in place for several days. It is helpful to mark in some manner (e.g., colour marker pen) those bait stations which receive the greatest activity. In this way, the most heavily infested areas can receive the most attention. Likewise, those bait containers receiving little attention may be picked up or moved. Night time (dusk) or early morning inspections will also aid in revealing the areas of the facility with the greatest activity and serve as a guide as to where to concentrate the placements of bait. The rotation baiting method as described for high rise facilities can also be useful in shallow pit facilities. The bait containers can be placed along the edges of each walkway or in the dry pit below the cages, started at both ends of the house and moved 0.3m every three days towards the opposite end of the house.

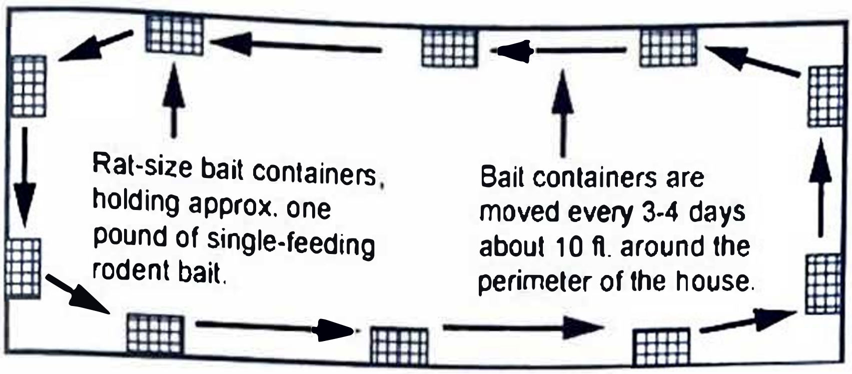


Figure 3.3: The rotation baiting method

Figure 3.4: Location of bait containers placed in the UPMKB chicken

3.4 Density Analysis

The trap/night method used in residential randomly selected blocks districts for at least 3 successive days. Traps installed at evening on day 1, checked in morning and evening of day 2, and locked open in the last check on the morning of day 3 with an average distance of 5–8 meters between each trap. Test time interval implemented from 23rd of February 2018 until 2nd of April 2018 in 20 spots randomly chosen in the chicken barn.

The equation for density analysis:

$$\text{Density} = \frac{\text{No. of total captured rodents}}{\text{Area of chicken barn } (m^2)}$$

CHAPTER 4

RESULTS

Along the capturing period of the rodents from 23rd of February until 2nd of April, a total of 16 rats has been caught around chicken barn at UPMKB. Surprisingly, all the rat species caught are *Rattus norvegicus* or also known as brown rats or Norway rats and also all are male.

Table 4.1. The details information of captured rodents

Date	Total	Location of cage	Weight/g	Sex
25/02/2018	1	K8	50	Male
29/02/2018	1	K17	250	Male
03/03/2018	1	K18	200	Male
05/03/2018	1	K20	180	Male
07/03/2018	2	K7	400	Male
		K11	80	Male
12/03/2018	1	K8	190	Male
17/03/2018	1	K8	210	Male
24/03/2018	1	K20	350	Male
27/03/2018	1	K8	360	Male

05/04/2018	1	K19	170	Male
02/04/2018	2	K7	80	Male
		K4	120	Male
10/04/2018	1	K20	220	Male
15/04/2018	1	K9	160	Male
19/04/2018	1	K8	270	Male

Table 4.2. List of total individuals captured based on location

Location	Total	Weight/g	Sex
K1	0	0	-
K2	0	0	-
K3	0	0	-
K4	1	120	Male
K5	0	0	-
K6	0	0	-
K7	2	400	Male
		110	Male
K8		50	Male
		190	Male
	5	210	Male
		360	Male
		270	Male
K9	1	160	Male
K10	0	0	-
K11	1	80	-
K12	0	0	-
K13	0	0	-
K14	0	0	-
K15	0	0	-
K16	0	0	-
K17	1	250	Male

K18	1	200	Male
K19	1	170	-
K20		180	Male
	3	350	Male
		220	Male

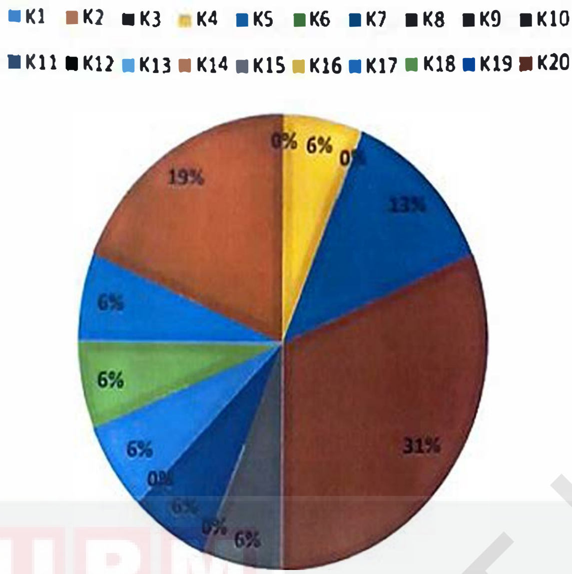


Figure 4.1: Percentage of individual rodent captured based on trap location

From Table 4.2, location K8 has the most total individual rats captured with a total of five rats and Figure 4.2 show that from total of 16 rats, 31% are captured from location K8.

Table 4.3. List of individuals captured based on week

Week	Total	Location
1	2	K8
		K17
2	4	K18
		K20
		K7
		K11
3	1	K8
4	1	K8
5	2	K20
		K8
6	3	K7
		K19
		K4
7	1	K20
8	2	K9
		K8

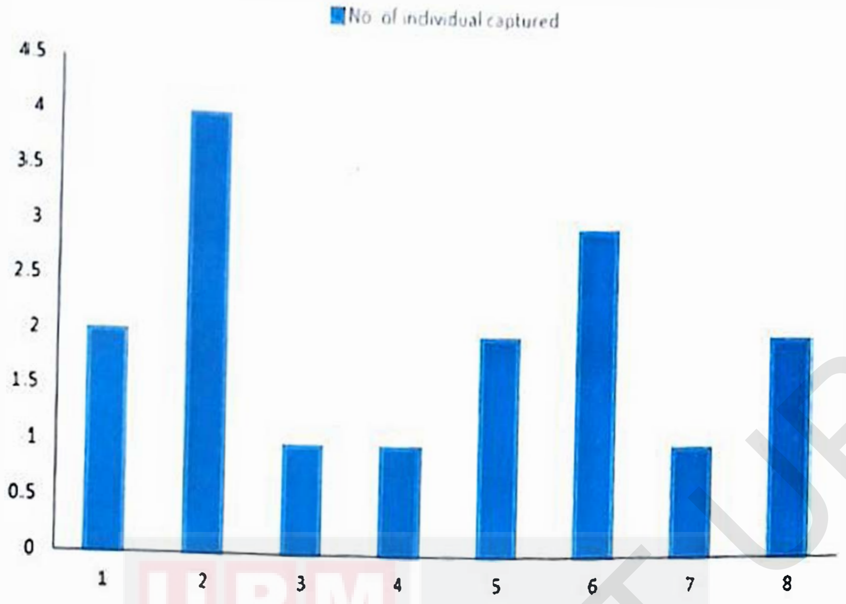


Figure 4.2: Number of individual captured based on week

From table 4.3, week two had the most total individual rats captured with a total of four rats on that week on four different location.

4.1 Density Analysis

$$\text{Density} = \frac{\text{No. of total captured rodents}}{\text{Area of chicken barn (m2)}}$$

$$D = \frac{16}{(25m)(7m)}$$

$$D = 4.48 / m^2$$

4.2 Feed Loss

Rodents eat poultry feed and they waste and contaminate more than they eat. With a modest estimate of their feed consumption at 10% of their body weight, the rats consume about 25 g per day and 9.1 kg per year. If that daily figure is converted to a yearly estimate and if as many as 20 rats are present in a poultry shed, the annual loss per shed could reach 0.18 ton.

Average total of UPMKB chicken barn loss in a month because of rodents:
Average weight of standard chicken pellet available is 25 kg, and cost of RM45 per bag, that's about RM1.80 per kg.

During the 2 months of the capturing period of rodents, a total of 16 individuals rodent captured, and the average weight of the rodents are:

$$\frac{50g + 250g + 200g + 180g + 400g + 80g + 190g + 350g + 360g + 170g + 80g + 120g + 320g + 160g + 270g}{16} \quad \frac{3180g}{16}$$

= 198.75g

If it eats 10% of its body weight, that is a total of about 19.875g weight of chicken pellet it eats in a day for one rats.

To calculate the price loss for the 2 month of capturing period, we calculate:

19.875g x 60 days = 1192.5g chicken pellet loss in 2-month, average about 1.2kg

If for a year, 1.2kg x 6 = 7.2kg feed loss for a year from a single rat.

Average price (RM) of chicken pellet per kilogram: $\frac{RM45}{25kg}$ = RM1.80 per kg

Average total loss for a year of UPMKB chicken barn: RM1.80 x 7.2kg = RM12.96 for a single rat.

Imagine, if a single rat can affect the food ratio loss up to RM12.96 per year, what if the population of rat is over 100, then the total loss is much greater in term of food feed loss.

CHAPTER 5

DISCUSSIONS

From the study conducted in chicken barn of Universiti Putra Malaysia Bintulu Campus, 16 total individuals of rodents have been captured during the studies and only 1 species of rodent had been identified, which was *Rattus norvegicus* or brown rats.

Brown rat considered a standout amongst the most serious mammalian pests ever known, the brown rat is a genuine omnivore, eating an immerse scope of food including invertebrates, frogs, small mammals, birds' eggs, scavenged meat and bones, cereals and seeds, fruit, carrion, and any food disposed of by humans. They are for the most part nocturnal, but like many mammals they turn out increasingly active in the day where they are undisturbed by humans. They generally move around on the ground, but at the same time are jumpers, climbers and swimmers.

Rattus norvegicus is a fairly huge member of the mouse family. On average, these rats achieve almost 400 mm nose-to-tail, and weigh 140 to 500 g. Males are typically bigger than females. In normal populaces, these rats are covered with coarse, brownish fur (sometimes splotched with black or white hairs) on their dorsal surface, which typically lightens to a grey or tan colour nearing the underside. Different strains of these rats reproduced in captivity might be white, brown, or black. The ears and tail are bald. The length of the tail is shorter than the length of the body. The ears of brown rats are commonly shorter than those of related species, and do not cover up the eyes when pulled down. Norway rats can be easily mistaken for black rats, however, the temporal ridges of the brown rat are straight, whereas those of the black rat are curved.

5.1 Behaviour

Behaviour is generally characterized as the activity and response of a living being relative to internal and external conditions in the environment. Behaviour can be conscious or unconscious. Ethology is the scientific investigation of behaviour of animals. Charles Darwin, in his book, the expression of the emotions in man and animals (Darwin 1872) made an early endeavour to clarify the complexity and variation of human and animal behaviour. He looked at behaviour from the foundation of evolutionary thought (Archer 1992). Oskar Heinroth in 1911 did a comparative investigation on the social behaviour of wild fowl with much enthusiasm in imprinting; this work was taken up by Konrad Lorenz (Archer 1992). Niko Tinbergen worked on observing animals in their regular surroundings habitat using experimentation, photography, filming and analysis, while Lorenz surrounded himself with his animals investigating the displays of similar species of birds (Archer 1992). An observed behaviour can be called instinctive, or natural, in that they happen in all individuals of a species under determined conditions.

Mostly nocturnal or active during sunset, brown rats go about digging burrows, scavenging for food, and preparing nests during these hours. Regularly, these rats relocate to residence in areas near water. They are incredible swimmers and are frequently referred to as "water rats." (Barnett 1963; Calhoun 1962; Hamilton 1998; Nowak and Paradiso 1983; Parker 1990)

Foraging behaviours can take the rats on long nightly excursions to regions known to be rich in food resources via learned routes. There is much learning limit in Norway rats. They are able to remember their way around complex sewer and burrow networks. Their capacity to learn has been thoroughly studied by psychologists (Barnett 1963; Calhoun 1962; Parker 1990).

Rats are for the most part fed a diet containing low fibre (5%), protein (20%) and fat (5-10%). Feed may be pelleted or powdered. The pelleted feed is provided as regular, breeder, certified, irradiated or autoclavable. Rats are normally supplied feed free choice and they eat 10-30 g a day (5 g/100 g body weight/day). Water is supplied free choice and they usually drink 20-50 ml a day (10 ml/100 g body weight/day).

Brown rat identification is simple. Brown rats are brown with scattered black hair on a long, heavy body. Their muzzles are shorter than other rats, and the underside appears white or grey. The tail and ears have a scaly appearance. Their tails are shorter than their body length and their ears and eyes are small relative to their body. Brown rats are larger than most other rat species.

The male social system of brown rats is generally subjected on the population density When the population density is low, the male rats end up territorial and in this instance each male will have his own territory. Furthermore, each male will defend the territories around the tunnel of at least one or more females and mate exclusively with them (Barnett 1958). A territory can be characterized as an area that is known to the rat and visited on a daily basis. On the contrary in a high population density circumstances, the males have overlapping home ranges and their communications with each other are not based on location or territory but rather on activity. In such conditions one rat normally turns out to be more socially dominant than other rats (Barnett 1958; Lott 1984). Home range refers to the total space occupied by the individual rat as it takes part in its various activities from day to day (Calhoun 1962).

Humans and farm animals have been infected and keep on to be contaminated with loads of rodent-carrying infectious organisms. This poses a nonstop danger of disease outbreak on livestock farms and in humans likewise. Therefore, a requirement for effective rodent control cannot be over-emphasized. Rodent control strategies that are carried out are typically geared towards decreasing the rodent population of a densely populated area drastically. Usually these strategies include the use of rodenticides, simply because the use of other control measures, for example, traps and ensuring good structural barriers are not adequate to effectively decrease the rat population (Cowan *et al.* 2003). Thus, the utilization of rodenticides seems to be the best rodent control measure. However, rodenticides use has its own downside since the accomplishment of such a strategy greatly relies on repeated application. These disadvantages include; wild and domestic animal poisoning, environmental hazards, and improvement of resistance in target species.

There is an interaction between the social system and feeding behaviour of the rat, called social learning. For instance, young rats will eat only food that adults in the colony have learned to eat and eventually prefer this diet (Galef 2001). It is also learned that a food that makes a rat ill may be poisonous and dangerous in the future and therefore avoided (Garcia *et al.* 1974).

5.2 Food Habits

Brown rats are excellent foragers and can survive quite easily as long as there is a relentless supply of any type of food and water. They particularly make use of their sense of smell and touch to locate food. In urban areas, they survive mainly on disposed human food, and anything else that can be eaten without any negative implications. Examination of a wild brown rat's stomach in Germany revealed 4000 items, generally plants although studies have shown that brown rats prefer meat when given the option (Nowak and Paradiso 1983). It has been reported that brown rats promptly adapt their feeding habits to various basic conditions in the environment (Klemann and Pelz, 2006).

Furthermore, rats always respond to human odour and it seems probable that in many situations wild rats may avoid objects that have recently been handled by man (Taylor *et al.* 1974). A study has been made by Howard and Marsh (1970) on the use of olfaction in rodent control, indicating that an attractive odour will increase the chances that most wild rodents will locate a bait carrying the odour, but the authors could not ascertain whether wild rats can be conditioned to associate an exotic odour with a palatable bait.

5.3 Management Plan to Control the Rodent's Population

Non-toxic glue boards will be utilized to trap and monitor for rodent populations inside the building. Non-toxic baits and/or non-toxic tracking powder may likewise be used to monitor for rodent activity. Multiple catch traps and/or snap traps may be utilized if there is proof of increased invasion or if five or more rodents are trapped on any inspection. If used, they will be placed in areas where they can't be messed with.

If bait stations are used, they will be attached or anchored to debilitate unsettling influence by non-authorized personnel. Each station will be marked with the name and address of the pest control company and the dates of installation and overhauling will be shown. The pest control technician will create outlines or maps showing the placement of bait stations, which will be kept up as feature of the pest control companies' administration record.

Poison tracking powder may be utilized by putting dust into wall voids or other concealed areas that are not treatable by any other means. Placement of poison tracking powder in tracking powder stations may also be considered if other baiting methods have not been fruitful due to bait shyness or resistance. Careful consideration will be given to their use with respect to the potential for exposure to building tenants and/or non-target animals, air development and moisture levels.

Use of liquid baits may be appropriate in circumstances where the supply of water is rare or non-existent. Only tip resistant professional liquid baiting containers will be utilized if this method of baiting is employed. Consideration will be given to environmental factors such as heat or cold. Placement of the containers will be resolved based on the risk of exposure to people or non-target animals and spilling or splashing liquid bait in areas sensitive to exposure and contamination.

CHAPTER 6

CONCLUSION

As a conclusion, the study of impact of rodents on poultry production in chicken barn of UPMKB has concluded that brown rats or *Rattus norvegicus* is the most common rodent species available there. Only one species can be identifying due to rodent pest control by the staff there before the study is conducted there. So, most of the rodent already dead or abstain from the study sites.

The study also found that the rodents had been affecting poultry production of UPMKB in greater values and also kill or spread diseases to chicken there. The investigation also gives attributes of identifying potential problem areas that might be contributing to rodent infestation within the facility, making recommendations for corrective measures that should be implemented and developing a comprehensive integrated pest management (IPM) plan. The IPM plan will utilize all techniques of rodent control which may include structural maintenance, sanitation, monitoring for rodent populations, mechanical and biological control and the judicious use of pesticides. These strategies will help to eliminate food, moisture and harbourage for rodents, making their survival more troublesome.

Pesticides will not be applied on a standard premise; however, they may be utilized as a tool to keep up rodent populations at or below an acceptable level. The determination of pesticides that may be used will be based on a pre-determined hierarchy which will utilize least toxic products as first choice. Proper implementation of this program will decrease the volume, toxicity and frequency of pesticide applications, thereby reducing the risk of potential exposure of building occupants who may be sensitive to their utilization.

REFERENCES

Akande, O.A. 2011. A study on wild rat behaviour and control on a pig farm. Second cycle, A1N, A1F or AXX (AXX). Uppsala: SLU, Dept. of Clinical Sciences

Backhans, A., and Fellström, C. 2012. Rodents on pig and chicken farms–A potential threat to human and animal health. *Infection ecology & epidemiology*, *2*(1), 17093.

Brunton, C.F.A., Macdonald, D.W., and Buckle, A.P. 1993. Behavioural resistance towards poison baits in brown rats, *Rattus norvegicus*. *Applied Animal Behaviour Science*, *38*(2), 159-174.

Corrigan, R.M. and Williams, R.E. 1986. The house mouse in poultry operations: Pest significance and a novel baiting strategy for its control. In: Proceedings of the Twelfth Vertebrate Pest Conference (1986).

Feng, A.Y., and Himsworth, C.G. 2014. The secret life of the city rat: A review of the ecology of urban Norway and black rats (*Rattus norvegicus* and *Rattus rattus*). *Urban Ecosystems*, *17*(1), 149-162.

Villafane, I.E.G. and Busch, M. 2007. Spatial and temporal patterns of brown rat (*Rattus norvegicus*) abundance variation in poultry farms. *Mammalian Biology-Zeitschrift für Säugetierkunde*, *72*(6), 364-371.

Hasson, R.H. 2010. A study in campaign for commensal rodents control in Baghdad area. *AL-TAQANI*, 14-19.

Himsworth, C.G., Jardine, C.M., Parsons, K.L., Feng, A.Y., and Patrick, D.M. 2014. The characteristics of wild rat (*Rattus* spp.) populations from an inner-city neighborhood with a focus on factors critical to the understanding of rat-associated zoonoses. *PLoS One*, *9*(3), e91654.

Inglis, I.R., Shepherd, D.S., Smith, P., Haynes, P.J., Bull, D.S., Cowan, D.P., and Whitehead, D. 1996. Foraging behaviour of wild rats (*Rattus norvegicus*) towards new foods and bait containers. *Applied Animal Behaviour Science*, *47*(3), 175-190.

Krebs, C.J., Boonstra, R., Gilbert, S., Reid, D., Kenney, A.J., and Hofer, E. J. 2011. Density estimation for small mammals from livetrapping grids: Rodents in northern Canada. *Journal of Mammalogy*, *92*(5), 974-981.

León, V., Fraschina, J., and Busch, M. 2009. Rodent control at different spatial scales on poultry farms in the province of Buenos Aires, Argentina. *International Biodeterioration & Biodegradation*, *63*(8), 1113-1118.

Meerburg, B.G., Bonde, M., Brom, F.W. A., Endepols, S., Jensen, A.N., Leirs, H., and Kijlstra, A. 2004. Towards sustainable management of rodents in organic animal husbandry. *NJAS-Wageningen Journal of Life Sciences*, *52*(2):195-205.

Palis, F.G., Singleton, G., Sumalde, Z., and Hossain, M. 2007. Social and cultural dimensions of rodent pest management. *Integrative Zoology*, *2*(3), 174-183.

Pelz, H.J., and Klemann, N. 2004. Rat control strategies in organic pig and poultry production with special reference to rodenticide resistance and feeding behaviour. *NJAS-Wageningen Journal of Life Sciences*, *52*(2), 173-184.

Fitzwater, W.D., and Prakash, I. 1973. *Handbook of vertebrate pest control*. Indian Council of Agricultural Research Krishi Anusandhan Bhavan Pusa; New Delhi.

Belmain, S., and Nala, R. 2002. Assessment of the impact of rodents on rural household food security and the development of ecologically-based rodent management strategies in Zambézia Province. *Natural Resources Institute. Final Technical Report*.

Reusken, C., v.d.Plaats, R., Opsteegh, M., de Bruin, A., and Swart, A. 2011. *Coxiella burnetii* (Q fever) in *Rattus norvegicus* and *Rattus rattus* at livestock farms and urban locations in the Netherlands: could Rattus spp. represent reservoirs for (re) introduction? *Preventive Veterinary Medicine*, *101*(1-2), 124-130.

Shafi, M.M., Ahmed, S.M., Pervez, A., and Ahmad, S. 1992. Enhancement of poison bait acceptance through taste additives in *Rattus norvegicus*. *Journal of Stored Products Research*, *28*(4), 239-243.

Shahwar, D., Hussain, I., Kawan, A., & Akrim, F. 2016. Influence of bait station design on bait uptake by rodents in poultry farms of Rawalpindi-Islamabad area, Pakistan. *International Biodeterioration & Biodegradation*, *107*, 17-20.

Shiels, A.B., and Pitt, W.C. 2014. A review of invasive rodent (*Rattus* spp. and *Mus musculus*) Diets on Pacific Islands. Proceedings of the 26th Vertebrate Pest Conference, March 3-6, 2014, Waikoloa, Hawaii.

Singleton, G. 2003. Impacts of rodents on rice production in Asia. IRRI Discussion Paper Series No. 45, 30 pp, Los Baños, Philippines.

Stenseth, N.C., Leirs, H., Skonhoft, A., Davis, S.A., Pech, R.P., Andreassen, H.P., & Zhang, Z. 2003. Mice, rats, and people: the bio-economics of agricultural rodent pests. *Frontiers in Ecology and the Environment*, *1*(7), 367-375.

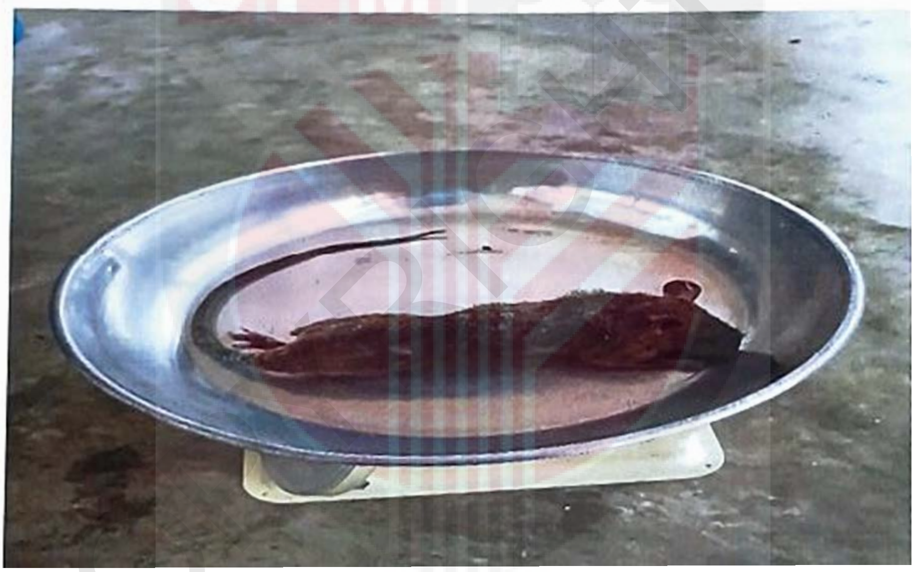
Takács, S., Musso, A.E., Gries, R., Rozenberg, E., Borden, J.H., Brodie, B., & Gries, G. 2017. New food baits for trapping house mice, black rats and brown rats. *Applied Animal Behaviour Science*. 200: 130–135.

Takahashi, L.K., and Lore, R.K. 1980. Foraging and food hoarding of wild *Rattus norvegicus* in an urban environment. *Behavioral & Neural Biology* 29(4), 527-531.

APPENDIX

Both picture show a brown rat (*rattus norvegicus*) captured in a trap and are weighed.

A brown rat that has been put to sleep by chloroform is being weighed



A brown rat is checked for gender determination after been put to sleep

Captured brown rat before subjected to chloroform

PUBLICATIONS OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled "Impact of Rodents on Poultry Production In UPMKB" by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Sarawak Campus and published in the form approved by the Faculty.

Muhamad Zaki Bin Mat Daut

Date: